

The Physical Setting

- ✓ The Universe
- ✓ The Earth
- ✓ Processes That Shape The Earth
- ✓ Structure of Matter
- ✓ Energy Transformations
- ✓ Motion
- ✓ Forces of Nature

THE PHYSICAL SETTING - The Universe
Grade K-2 (Benchmark 1 of 3)

By the end of the 2nd grade all students will know that --

There are more stars in the sky than anyone can easily count, but they are not scattered evenly.

Suggested Activity:

Show students a map of the sky. Ask students to try to count the stars. Tell them this picture is of only a part of the sky. Ask if they can see any pictures or patterns in the stars and how some stars are alike (size). Have the students make an actual observation of stars in the sky. Probe - how many stars are in the sky? What do your diagrams of the stars and their locations mean to you?

Embedded Assessment: Given a picture of the Big Dipper, students can discuss what it looks like and locate the constellation on a simple map among other unlabeled constellations.

Summative Assessment: Given pictures of constellations students will recognize that stars vary in size and are spaced closer together or farther apart.

Theme: Models

Process: Experimental Proficiency, esp. formulate hypothesis, observing

NASA Space Grant Program Center located at Brown University (863-2889) has celestial maps and other resources available for teachers.

THE PHYSICAL SETTING - The Universe
Grade K-2 (Benchmark 2 of 3)

By the end of the 2nd grade all students will know that --

The sun can be seen only in the daytime, but the moon can be seen sometimes at night and sometimes during the day. The sun, moon, and stars all appear to move slowly across the sky.

Suggested Activity:

Build a model to show the rotation of the sun, moon and the earth. Use your shadow as a guide. Caution children NOT to look directly at the sun.

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| Embedded Assessment: | The students can describe the movement of the sun across the sky. |
| Summative Assessment: | Ask students to predict where the sun will be seen in the next two hours. Students can also be asked to repeat this activity with the moon or with a particular star. |
| Theme: | Models, Systems |
| Process: | Experimental Proficiency, esp. diagramming, observing, following a sequence of activities, psychomotor proficiency |

THE PHYSICAL SETTING - The Universe
Grade K-2 (Benchmark 3 of 3)

By the end of the 2nd grade all students will know that --

The moon looks a little different every day, but looks the same again about every four weeks.

Suggested Activities:

Make a monthly calendar (30 or 31 days) on a bulletin board or large classroom chart. Each day have a student add the shape of the moon they have observed and sketched the previous night. Record the number of shapes for the moon and the days involved. Take students to local planetarium. Look at videos and books dealing with the moon. Ask students how they think the moon affects them.

Embedded Assessment: Students record moon's appearance on Classroom Moon Calendar.

Summative Assessment: Student predict phases of the moon for future/prior months.

Theme: Models, Constancy & Change

Process: Manipulating Information, esp. inferring, identifying patterns and relationships

THE PHYSICAL SETTING - The Universe
Grade 3-5 (Benchmark 1 of 5)

By the end of the 5th grade all students will know that --

The patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons.

Suggested Activity:

Students choose a constellation and research the type of stars found in their constellation. The constellations then are modeled and a mini-planetarium can be presented (paper towel or toilet tissue roll with constellation punched on construction paper over the end and flashlight).

Students who are able to observe stars at night can keep a constellation diary and observe their chosen constellation every night. They should look at the constellation at different times and plot where it is found. This activity, if repeated in another season, leads to many additional insights for the students.

Embedded Assessment: Given a card with pictures they can identify five constellations.

Summative Assessment: When asked if their constellation will be visible in another season, they will indicate that it may not be (depending on the movement of the constellation).

Theme: Models

Process: Language Proficiency, Psychomotor Proficiency

Visit a planetarium! Roger Williams Park Planetarium (785-9457), Middletown Planetarium at the Middle School, Worcester Museum of Science. Or use a portable planetarium, like Star Lab.

THE PHYSICAL SETTING - The Universe
Grade 3-5 (Benchmark 2 of 5)

By the end of the 5th grade all students will know that --

Telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye.

Suggested Activity:

Take a field trip to an observatory. Work with students in advance to set up interview/questions. Allow students to use binoculars or borrow a telescope and see how they increase visibility. Compare pictures taken with various telescopes with different magnifications.

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| Embedded Assessment: | Students list things they can see better with a telescope. |
| Summative Assessment: | Students compare a view of the sky with the naked eye, binoculars, a small telescope, and a telescope in an observatory. |
| Theme: | Continuity and Change |
| Process: | Language Proficiency |

Visit the observatory at Brown University; it is open to the public every Wednesday. Also try the Seagrave Observatory on Peepload Road in Scituate, the Ninigret Observatory in Charlestown, and the CCRI Warwick Campus.

THE PHYSICAL SETTING - The Universe
Grade 3-5 (Benchmark 3 of 5)

By the end of the 5th grade all students will know that --

Planets change their positions against the background of stars.

Suggested Activity:

Observe a planet (Mars or Venus are good candidates) outside at your home for a specific period of time. Draw a diagram of what you see, recording its position in relation to nearby stars. Compare your findings with those of your classmates. Discuss point of reference so changes can be plotted.

Embedded Assessment: Chart of planetary locations at 6pm, 7pm, and 8pm.

Summative Assessment: Predict the position of the planet at 9pm and 10 pm.

Theme: Models

Process: Psychomotor Proficiency, esp. recording data, creating diagrams

THE PHYSICAL SETTING - The Universe
Grade 3-5 (Benchmark 4 of 5)

By the end of 5th grade, all students will know that --

The earth is one of several planets that orbit the sun, and the moon orbits around the earth.

Suggested Activity:

Groups of students construct a scale model of the solar system inside or outside the school. Alternatively, use your geographic location as the basis (center) of your scale model and determine where the other planets would be. Each student researches a particular planet.

Embedded Assessment: Students compare movement of different planets around the sun.

Summative Assessment: Students make mobiles of the solar system.

Theme: Models, Systems

Process: Psychomotor Proficiency, esp. manipulating materials

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THE PHYSICAL SETTING - The Universe
Grade 3-5 (Benchmark 5 of 5)

By the end of the 5th grade all students will know that --

Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light. The sun is a star.

Suggested Activity:

Give three students identical flashlights or some spheres of the same size. Have them stand at different distances. Students observe the difference in apparent size compared to distance. Get light bulbs of different wattage and different colors to simulate how stars vary.

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| Embedded Assessment: | Students explain how apparent size and actual distance are related. |
| Summative Assessment: | Have students in teams decide what the sun would look like from Pluto. |
| Theme: | Models |
| Process: | Psychomotor Proficiency |

THE PHYSICAL SETTING - The Universe
Grade 6-8 (Benchmark 1 of 4)

By the end of the 8th grade all students will know that --

The sun is a medium-sized star located near the edge of a disk-shaped galaxy (Milky Way) of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot.

Suggested Activity:

Visit planetarium, contact NASA for computer program, pictures, etc. Help students locate the Milky Way and prominent galaxies in the night sky.

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| Embedded Assessment | Look at photographs, identify the differences between a galaxy and a star. |
| Summative Assessment: | Using a diagram of our own galaxy and the approximate position of our solar system, explain the phenomenon known as the Milky Way. |
| Theme: | Systems |
| Process: | Developing Explanatory Frameworks |

NASA Space Grant Program Center located at Brown University (863-2889) has celestial maps and other resources available for teachers.

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THE PHYSICAL SETTING - The Universe
Grade 6-8 (Benchmark 2 of 4)

By the end of the 8th grade all students will know that --

The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years. Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past.

Suggested Activity:

Use a visual and auditory device, such as banging cymbals or popping a balloon, so that the student can see the device go off before they hear it. This should be done in a large area - long corridor, field, etc. Use a stopwatch to time it. Make reference to thunder and lightning. Which comes first? Explain.

Pass out solar system chart with the astronomical distances from the sun. Have students calculate how far light travels in a year. With the use of a calculator, figure out how long it will take the light from the sun to reach the various planets.

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| Embedded Assessment | Have students explain why we see some activities before we hear them. |
| Summative Assessment: | Have students solve distance/time problems based upon the information given in charts you have earlier distributed. |
| Theme: | Scale |
| Process: | Mathematical Proficiency and Manipulating Information |

Check out Odyssey, an astronomy magazine for kids, Cobblestone Publishing Inc., 7 School St., Peterborough, NH 03458, 603-924-7209, fax 603-924-7380.

THE PHYSICAL SETTING - The Universe
Grade 6-8 (Benchmark 4 of 4)

By the end of the 8th grade all students will know that --

Large numbers of chunks of rock orbit the sun. Some of those that the earth meets in its yearly orbit around the sun glow and disintegrate from friction as they plunge through the atmosphere--and sometimes impact the ground. Other chunks of rocks mixed with ice have long, off-center orbits that carry them close to the sun, where the sun's radiation (of light and particles) boils off frozen material from their surfaces and pushes it into a long, illuminated tail.

Suggested Activity:

With appropriate resource materials, find information about objects from outer space that have reached the earth's surface. List the damage caused by these objects and what they have taught us about extraterrestrial geology. Place liquid plaster of Paris in a plate or tray coated with petroleum jelly, drop rocks of different sizes from different heights to observe craters formed. Visit museum and observe fragments of meteors.

Embedded Assessment: Students will develop a time line presenting their findings.

Summative Assessment: Have students research a speculative theory linking dinosaur extinction to asteroid impact (Alvarez thesis). Have the teacher prepare some models of impact craters and present them to the students for hypotheses about the height, size and direction of the meteorite impact.

Theme: Models

Process: Developing Explanatory Frameworks

THE PHYSICAL SETTING - The Universe
Grade 9-12 (Benchmark 1 of 4)

By the end of the 12th grade all students will know that --

The stars differ from each other in size, temperature, and age, but they are made up of the same elements that are found on the earth and behave according to the same physical principles. Unlike the sun, most stars are in systems of two or more stars orbiting around one another (binary stars).

Suggested Activity:

Flame test and use of spectroscope to illustrate elements contained in stars and why star colors vary.

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| Embedded Assessment | Students will create a chart of the results of the flame test. |
| Summative Assessment: | Given a star's color and suitable reference materials, the student will be able to identify the likely predominant constituent elements. |
| Theme: | Systems |
| Process: | Manipulating Information |

THE PHYSICAL SETTING - The Universe
Grade 9-12 (Benchmark 2 of 4)

By the end of the 12th grade all students will know that --

On the basis of scientific evidence, the universe is estimated to be over ten billion years old. The current theory is that its entire contents expanded explosively from a hot, dense, chaotic mass (the 'Big Bang Theory'). Stars condensed by gravity out of clouds of molecules of the lightest elements until nuclear fusion of the light elements into heavier ones began to occur. Fusion released great amounts of energy over millions of years. Eventually, some stars exploded, producing clouds of heavy elements from which other stars and planets could later condense. The process of star formation and destruction continues.

Suggested Activity:

View the movie "The Universe". Demo black balloon with painted stars or dots as balloon is blown up - the expanding balloon will demonstrate the expanding universe. Read and discuss a Brief History of Time by Stephen Hawkins.

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| Embedded Assessment | Students will be able to state the general outlines of the Big Bang Theory. |
| Summative Assessment: explain | Students will be able to summarize evidence for the Big Bang Theory and employ the history of astronomy to why it is likely not the final word on the subject. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks. |

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THE PHYSICAL SETTING - The Universe
Grade 9-12 (Benchmark 4 of 4)

By the end of the 12th grade all students will know that --

Mathematical models and computer simulations are used in studying evidence from many sources in order to form a scientific account of the universe.

Suggested Activity:

Visit the Brown University NASA facility. Access computer simulations via the Internet. Brown University also has simulation programs available for loan.

Embedded Assessment: Students will submit a report detailing their visit.

Summative Assessment: Students will successfully use a computer program to predict the future motion and position of a celestial body.

Theme: Constancy and Change

Process: Psychomotor Proficiency

Contact the CIS Receptionist at the Graphics Lab of Brown University (863-7693) for information on borrowing computer simulation software.

THE PHYSICAL SETTING - The Earth
Grade K-2 (Benchmark 1 of 3)

By the end of the 2nd grade all students will know that --

Some events in nature have a repeating pattern. The weather changes some from day to day, but things such as temperature and rain (or snow) tend to be high, low, or medium in the same months every year.

Suggested Activity:

Create season charts linking weather, clothing, recreation. Have students list the months, and in small groups apply the appropriate labels 'hot', 'warm', 'cool' or 'cold' next to each. Create a daily temperature chart. What types of seasonal changes do students see in hardware or other local store displays?

Embedded Assessment: Using old catalogues match clothes to seasons. Ask if ALL the days in April are warm.

Summative Assessment: Dress a tree by seasons (leaves, buds, blossoms, fruit, etc.)

Theme: Constancy and Change

Process: Manipulating Information, esp. developing generalizations

THE PHYSICAL SETTING - The Earth
Grade K-2 (Benchmark 2 of 3)

By the end of the 2nd grade all students will know that --

Water can be a liquid or a solid and can go back and forth from one form to the other. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing.

Suggested Activity:

Measure a specific quantity of water and transfer it to an unbreakable container. Mark the level before freezing, after freezing, and after melting.

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| Embedded Assessment: | Completion of a student designed chart and diagrams illustrating their predictions and the results obtained. |
| Summative Assessment: | Melt an ice cube and measure the water. Ask how much water there was before the ice cube was frozen. |
| Theme: | Constancy and Change |
| Process: | Experimental Proficiency, Mathematical Proficiency |

THE PHYSICAL SETTING - The Earth
Grade K-2 (Benchmark 3 of 3)

By the end of the 2nd grade all students will know that --

Water left in an open container disappears, but water in a closed container does not disappear.

Suggested Activity:

Place equal quantities of water in two clear containers. Mark level of water in each container. Cover one container tightly, place both containers in a warm sunny place for several days. Discuss the results.

Embedded Assessment: Two wet sponges, two apples, etc.; one in plastic sandwich bag and one in the air. Students explain why there is a difference. Does water really disappear?

Summative Assessment: Given a series of life situations students will relate them to the benchmark. Where does a mud puddle go? Why do clothes dry on a clothesline? Having no towel, how do you dry off after swimming?

Theme: Constancy & Change

Process: Manipulating Information

Children are usually fascinated by the evaporation of liquids from fruits and vegetables. Pursue this principle with dried fruits: raisins, dried apricots or apples, etc. One or more parents may regularly dry fruit and share their experiences and expertise.

THE PHYSICAL SETTING - The Earth
Grade 3-5 (Benchmark 1 of 4)

By the end of the 5th grade all students will know that --

Things on or near the earth are pulled toward it by the earth's gravity.

Suggested Activity:

Drop objects which differ greatly from one another. Discuss how objects vary in size, weight, color, shape. Focus on the fact that although the rates may vary, all objects come down.

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| Embedded Assessment: | Discuss what all the objects have in common. What could be pulling them down? |
| Summative Assessment: | What would happen if you dropped a ball in Australia? Dropped it while flying in an airplane? |
| Theme: | Continuity and Change |
| Process: | Manipulating Information, esp. developing generalizations |

THE PHYSICAL SETTING - The Earth
Grade 3-5 (Benchmark 2 of 4)

By the end of the 5th grade all students will know that --

Like all planets and stars, the earth is approximately spherical in shape. The rotation of the earth on its axis every 24 hours produces the night-and-day cycle. To people on earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the earth once a day.

Suggested Activities:

Put a pin in a ball to represent a person. Using a flashlight and the ball, have a child rotate the ball in front of a stationary light. Have the children experience what it feels like to view their surroundings when sitting on a slowly spinning stool.

Embedded Assessment: What does the flashlight represent? When does the person see light? When is the person in darkness? Discuss the concept of a sun dial.

Summative Assessment: What would a day be like if the earth did not rotate?

Theme: Models

Process: Psychomotor Proficiency, esp. manipulating materials

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THE PHYSICAL SETTING - The Earth
Grade 3-5 (Benchmark 4 of 4)

By the end of the 5th grade all students will know that --

Air is a substance that surrounds us, takes up space, and whose movement we feel as wind.

Suggested Activities:

Blow up balloons and have students release the air on their skin. Take a paper or plastic bag and collect a bag of air. Pop it with a smack. Put a crumpled paper towel in the bottom of a glass, turn the glass upside down and place it in a bowl of water. Students can spin on a stool and use 'fins' (hold out pieces of paper) to illustrate air resistance. Weigh a sports ball inflated and uninflated.

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| Embedded Assessment | Students will write a story about how the air entered the bag or why the paper towel didn't get wet. Have students explain how a fan works. |
| Summative Assessment: | Have students relate their experiences from the balloons, the bags and the glass/paper towel to explain what they have inferred about air. |
| Theme: | Constancy and Change |
| Process: | Manipulating Information and Developing Explanatory Frameworks |

Invite a meteorologist (or radio/television weather reporter) to visit the school. Have students collect local and national weather maps to observe the importance of air masses, their movement, and weather prediction. Have students predict weather daily and weekly and assess their accuracy.

THE PHYSICAL SETTING - The Earth
Grade 6-8 (Benchmark 1 of 11)

By the end of the 8th grade all students will know that --

We live on a relatively small planet, the third from the sun in the only system of planets definitely known to exist (although other, similar systems may be discovered in the universe).

Suggested Activity:

Charge students to locate information on the relative sizes and positions of the planets. Have students make a scale drawing using a set size for the earth as the standard. Discuss the probability of other planetary systems. Discuss what it might be like to live on another planet.

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| Embedded Assessment | Evaluate scaled drawing according to the chart. |
| Summative Assessment: | Ask students to express in words the size of the earth in relationship to other planets. |
| Theme: | Scale |
| Process: | Manipulating Information, esp. identifying patterns and relationships |

An astronomer at Penn State has recently reported observational evidence of another star with orbiting planets. Students can investigate this discovery and its acceptance/rejection by the astronomical community.

THE PHYSICAL SETTING - The Earth
Grade 6-8 (Benchmark 2 of 11)

By the end of the 8th grade all students will know that --

The earth is mostly rock. Three-fourths of its surface is covered by a relatively thin layer of water (some of it frozen), and the entire planet is surrounded by a relatively thin blanket of air. It is the only body in the solar system that appears able to support life. The other planets have compositions and conditions very different from earth.

Suggested Activity:

Design a scale model to represent the relative size of the earth and the layers of water and air surrounding it. Have small groups create scale models representing selected planets and explain the difference between their particular planet and earth.

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| Embedded Assessment: | Have students list factors unique to the earth which support life. |
| Summative Assessment: | Place students in the year 2035 as professional astronomers who have just discovered an earth-like planet and related bodies in a nearby star system. Have them describe the system and its associated planets. |
| Theme: | Scale |
| Process: | Language Proficiency and Psychomotor Proficiency |

THE PHYSICAL SETTING - The Earth
Grade 6-8 (Benchmark 3 of 11)

By the end of the 8th grade all students will know that --

Everything on or anywhere near the earth is pulled toward the earth's center by gravitational force.

Suggested Activity:

Have students answer the question -- if gravity were gradually decreasing on earth, what accommodations would need to be made at home, at school, in industry, in planning for the future? Collect findings, predictions and design a mural for the school to encourage ideas from peers and faculty.

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| Embedded Assessment: | Discuss the difference in a person's weight between the earth and the moon. |
| Summative Assessment: | How did NASA compensate for the decreased gravity on the moon? |
| Theme: | Systems |
| Process: | Developing Explanatory Frameworks, esp. linking concepts and principles |

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THE PHYSICAL SETTING - The Earth
Grade 6-8 (Benchmark 4 of 11)

By the end of the 8th grade all students will know that --

Because the earth turns daily on an axis that is tilted relative to the plane of the earth's yearly orbit around the sun, sunlight falls more intensely on different parts of the earth during the year. The difference in heating of the earth's surface produces the planet's seasons and weather patterns.

Suggested Activity:

Draw a small grid on the blackboard. Shine a flashlight on the grid while holding it perpendicular; and at 30, 45, and 90 degree angles. At each angle have a student draw the circle of light, using a different color for each angle. Using a diagram of the earth or a globe, show how the tilt of the earth affects the amount of light on a given area, contributing to seasons. Areas could be calculated. Access international weather information from the Internet.

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| Embedded Assessment | Have each student explain the activity and how it relates to the seasons. |
| Summative Assessment: | Given the statement that during summer we are farther from the sun, have students explain the warmth of the summer. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks, esp. creating and testing physical models |

THE PHYSICAL SETTING - The Earth
Grade 6-8 (Benchmark 5 of 11)

By the end of the 8th grade all students will know that --

The moon's orbit around the earth once in about 28 days changes what part of the moon is lighted by the sun and how much of that part can be seen from the earth-- the phases of the moon, but the same side of the moon always faces the earth.

Suggested Activity:

Have students make a 28 day diary (have students do this the month before). They are to look at the moon the same time every day and then record where it is located in the sky (a straw on a protractor stand can be used to measure the angle of inclination) and the shape it has. Design an activity to model that part of the moon facing the sun that would be illuminated - e.g., using ping pong ball 1/2 black and 1/2 unpainted and pass it around in circular motion around a lighted bulb.

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| Embedded Assessment | Check daily diary |
| Summative Assessment: | By using diagrams, have students show how the phases of the moon are created. |
| Theme: | Systems |
| Process: | Developing Explanatory Frameworks, esp. creating and testing physical models |

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THE PHYSICAL SETTING - The Earth
Grade 9-12 (Benchmark 1 of 2)

By the end of the 12th grade all students will know that --

Life is adapted to conditions on the earth, including the force of gravity that enables the planet to retain an adequate atmosphere, and an intensity of radiation from the sun that allows water to cycle between liquid and vapor.

Suggested Activity:

Discuss the possibility of a water cycle existing on Mars.

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| Embedded Assessment | Recognize the components of the water cycle; evaporation, condensation, precipitation, etc. |
| Summative Assessment: | Students will describe the water cycle and its role in life on earth. |
| Theme: | Systems |
| Process: | Manipulating Information |

NASA Space Grant Program Center located at Brown University (863-2889) has maps and other resources available for teachers

THE PHYSICAL SETTING - The Earth
Grade 9-12 (Benchmark 2 of 2)

By the end of the 12th grade all students will know that --

Weather (in the short run) and climate (in the long run) involve the transfer of energy in and out of the atmosphere. Solar radiation heats the land masses, oceans, and air. Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the oceans results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different densities causes them to rise or fall--and such circulation, influenced by the rotation of the earth, produces winds and ocean currents.

Suggested Activity:

Investigate how El Niño affects weather - does it affect ocean currents or do ocean currents affect it? The Rossby Wave is a wave which originates in Southern Asia and travels across the Pacific. It seems to cycle with El Niño.

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| Embedded Assessment | Students collect and analyze recent weather data. |
| Summative Assessment: | Students present findings and conclusions as to whether the Rossby Wave and El Nino are connected. |
| Theme: | Systems |
| Process: | Manipulating Information |

Check with the local cable company (Cable TV of East Providence 438-7953; Cox Cable 946-3830; Dimension Cable 828-2288; Full Channel TV 247-1253) for offerings on the Weather Channel, Discovery Channel, or other weather resources.

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade K-2 (Benchmark 1 of 3)

By the end of the 2nd grade all students will know that --

Chunks of rock come in many sizes and shapes, from boulders to grains of sand and even smaller.

Suggested Activity:

Students start a collection of rocks. In observing the settling of sand and rocks in a bottle of water, students discern different sizes of particles and layers of rock and sediment. A trip to a gravel pit or rocky shore of RI would be a great collection spot.

Embedded Assessment Students will draw what they see and identify the various sized particles.

Summative Assessment: Given assorted rocks, students can sort them by size and shape.

Theme: Models

Process: Manipulating Information, esp. classifying

Try these local resources on Rhode Island geology:

Cain, J.A. 1986. Geology of Rhode Island. *Rocks and Minerals* 61(5): 257-263.

Quinn, A.W. 1976. *Rhode Island Geology for the Non-Geologist*. Providence, RI: Rhode Island Department of Natural Resources.

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 6-8 (Benchmark 3 of 7)

By the end of the 8th grade all students will know that --

Sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and are cemented together by precipitation of dissolved minerals to form solid rock again.

Suggested Activity:

In a plastic bottle, dissolve one stick of chalk in 8 oz. of water. Add 1-2 cm of sand (2-3 different kinds) in layers until the bottle is filled. Use sand collected from the shores of RI. A small shell can be added between layers to represent fossils. Set aside to dry for several months without the cap.

Embedded Assessment: Students will draw and label the components of their 'rock'.

Summative Assessment: Ask students to find a rock similar to their created rock.

Process: Developing Explanatory Frameworks, esp. creating physical models

Theme: Models

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THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 6-8 (Benchmark 4 of 7)

By the end of the 8th grade all students will know that --

Sedimentary rock buried deep enough may be reformed by pressure and heat, perhaps melting and recrystallizing into different kinds of rock (metamorphism). These re-formed rock layers may be forced up again to become land surface and even mountains. Subsequently, this new rock too will erode. Rock bears evidence of the minerals, temperatures, and forces that created it.

Suggested Activity:

Students will go into the field and find metamorphic rock which is all over Rhode Island.

Embedded Assessment: Students will discuss the processes of the rock cycle.

Summative Assessment: Using an appropriate laboratory activity, students will identify the major rock classifications.

Process: Manipulating Information

Theme: Constancy and Change

Professor Bruno Giletti at Brown University is available to help you find sites for this activity (863-2242). He suggests two very good sites -

1. Where the old visitor center was at the junction of Rtes. 295 and 95 on westbound side (parking may be difficult here); and
2. Jamestown Island off of old Rte. 138, next to the old Jamestown Bridge. Standing on the shoreline you can see a series of outcrops - high grade metamorphic.

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 6-8 (Benchmark 5 of 7)

By the end of the 8th grade all students will know that --

Thousands of layers of sedimentary rock confirm the long history of the changing surface of the earth and the changing life forms whose remains are found in successive layers. The youngest layers are not always found on top, because of folding, breaking, and uplift of layers.

Suggested Activity:

Make layers of bread, peanut butter and jelly, and cut and push the layers together to observe lifting and folding. Complete activity available in AIMS "Peanut Butter and Jelly Geology" lesson.

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|-----------------------|---|
| Embedded Assessment: | Students understand that youngest layers may not always be on top. |
| Summative Assessment: | Show students a picture (or take them to) a roadcut and ask them to suggest various hypotheses that could account for its appearance. |
| Process: | Manipulating Information, esp. identifying patterns and relationships |
| Theme: | Models |

More local resources for help in this areas --

Milkowski, G. 1981. *Beach processes in Southern Rhode Island*. Narrangansett, R.I.: Rhode Island Sea Grant, University of Rhode Island.

Murray, D.P. 1988. *Rhode Island: The Last Billion Years*. Kingston, R.I.: University of Rhode Island

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 6-8 (Benchmark 6 of 7)

By the end of the 8th grade all students will know that --

Although weathered rock is the basic component of soil, the composition and texture of soil and its fertility and resistance to erosion are greatly influenced by plant roots and debris, bacteria, fungi, worms, insects, rodents, and other organisms.

Suggested Activities:

Sample soils in different places in the school yard (core sample, dig a pit, etc., using the same size sample in each area) and compare with other sites in state by partnering with one or more distant schools. Have students relate surface appearance to soil structure, texture, moisture, and color. Take two pans of soil (large rectangular size), one with grass, planted or turf, one just with soil. Place at an incline and sprinkle water on the top of each pan. Watch for erosion.

Alternatively, use the module 'River Cutters' available as part of the GEMS series from the Lawrence Hall of Science (see resources section).

| | |
|-----------------------|--|
| Embedded Assessment: | Students indicate an understanding of the relationship between soil constituents and fertility, erosion, etc. They can describe how the organisms they find affect the soil. |
| Summative Assessment: | Show students a picture of a particular environment and have them predict what the soil below would look like. |
| Process: | Manipulating Information, esp. identifying patterns and relationships. |
| Theme: | Systems |

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 6-8 (Benchmark 7 of 7)

By the end of the 8th grade all students will know that --

Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms.

Suggested Activity:

Have students predict the environmental consequences of a proposed development in their community. If possible, include public hearings, site visits and interviews. Alternatively, obtain and use the module available from the New York Science, Technology and Science Education Project.

| | |
|-----------------------|--|
| Embedded Assessment: | Students research the effects of the proposed development. |
| Summative Assessment: | Write an editorial for the newspaper describing your position on the class issue. |
| Process: | Proficiency in Informed Action, esp. identifying intended and unintended consequences of action. |
| Theme: | Systems |

For local resources look for:

Carpenter, V. 1993. *The Piping Plover: A History*. The Nature Conservancy. Providence, R.I.: The Nature Conservancy.
Dickson, D.R. and C. L. McAfee. 1988. *Forest Statistics for Rhode Island - 1972 and 1985*. Resource Bulletin E-104. Broomall, Pa: United States Department of Agriculture, Forest Service.

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*From Mr. Tappero's Class
West Warwick High School
West Warwick, Rhode Island
High School Activity*

Using Simulations to Make Land Use Decisions

"Be aware, when considering claims, that when people try to prove a point, they may select only the data that support it and ignore any that would contradict it."

We use a simulation game to show the mechanism of making land use decisions. The students have all had some time studying values and uses of urban, suburban and rural lands. They are given a map of 'Centerpiece City' showing the metropolis, suburban fringe and surrounding countryside, including a one mile square piece of abandoned farmland that has just been willed to the city. They also receive a list of characteristics of the city and a few notions strongly held by the people in the city.

Role cards are passed out at random. There must be three town council cards. The remaining cards are equal to the students in the class and are of three general categories - (1) environmentalist; (2) private business owner; and (3) city department (board of education, department of public works, recreation commission, etc.). Each student must then prepare an oral presentation with a visual of their idea of how the newly acquired land should be used. We use a five minute presentation with three minutes of questions from the 'audience'. The Town Council then evaluates each presentation on an objective grid they have developed by playing their role. The teacher should give just enough help to the Council to ensure an objective and numerical system of evaluation.

What happens is ALWAYS predictable. The business groups always win and the environmental groups always lose. This information can be used by the teacher in many different ways, depending on the age level and maturity of the students. The reason for the predictable outcome is the fact that the Council will invariably construct an evaluation instrument that is based on the financial stability of the city. This fact can lead to much discussion and even the construction (classroom, homework or collaborative project) of an evaluation instrument that more equally considers both human needs and environmental conservation.

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 9-12 (Benchmark 1 of 5)

By the end of the 12th grade all students will know that --

Plants alter the earth's atmosphere by removing carbon dioxide from it, using carbon and light energy to make sugars, releasing oxygen. This process, commonly known as photosynthesis, is largely responsible for the oxygen content of the air.

Suggested Activity:

A sample of elodea can be used to produce oxygen. Various tests (e.g., the chemistry of the light and dark reactions) can be used to verify this.

Embedded Assessment: Given the chemical equation representing photosynthesis, student will recognize the components of this process.

Summative Assessment: How might clear cutting a significant number of forests alter the earth's atmosphere?

Theme: Systems

Process: Manipulating Information

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 9-12 (Benchmark 2 of 5)

By the end of the 12th grade all students will know that --

The formation, weathering, sedimentation, and reformation of rock constitute a continuing "rock cycle" in which the total amount of material stays the same as its forms change.

Suggested Activity:

Use appropriate AV materials, rock identification, manuals or kits and visit appropriate sites to observe evidence of any of the above processes.

Embedded Assessment: Identify and list characteristics of above processes

Summative Assessment: Given a slide or photograph of a RI geological formation, the student will be able to discuss and identify which processes are applicable.

Theme: Constancy & Change

Process: Manipulating Information

The Graduate School of Oceanography at URI will provide information and presentations on geology and related topics. Contact H. Sigurdsson, Professor at 792-6596.

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 9-12 (Benchmark 3 of 5)

By the end of the 12th grade all students will know that --

The slow movement of material within the earth results from heat flowing out from the deep interior and the action of gravitational forces on regions of different density.

Suggested Activity:

Bring a beaker of water to a boil and then add push pins. Pins will begin to rise and fall, demonstrating a convection cell. Make connection to convection in air and the effect of this natural phenomenon on weather.

Embedded Assessment

Describe the dynamics of movement in a convection cell.

Summative Assessment:

Students will be able to relate this movement to the convection currents in the earth.

Theme:

Models

Process:

Manipulating Information

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THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 9-12 (Benchmark 4 of 5)

By the end of the 12th grade all students will know that --

The solid crust of the earth--including both the continents and the ocean basins--consists of separate plates that ride on a denser, hot, gradually deformable layer of the earth. The crust sections move very slowly, pressing against one another in some places, pulling apart in other places. Ocean-floor plates may slide under continental plates, sinking deep into the earth. The surface layers of these plates may fold, forming mountain ranges. This is known as 'plate tectonics'.

Suggested Activity:

Demo - Use plate tectonics model blocks as well as overhead transparencies of earthquake zones and faults.

| | |
|-----------------------|--|
| Embedded Assessment | Recognize the relationship between earthquakes and fault zones. |
| Summative Assessment: | Given a plate tectonics map and a list of cities students will be able to predict which ones might have earthquakes. |
| Theme: | Systems |
| Process: | Manipulating Information, esp. interpreting data |

THE PHYSICAL SETTING - Processes That Shape the Earth
Grade 9-12 (Benchmark 5 of 5)

By the end of the 12th grade all students will know that --

Earthquakes often occur along the boundaries between colliding plates, and molten rock from below creates pressure that is released by volcanic eruptions, helping to build up mountains. Under the ocean basins, molten rock may well up between separating plates to create new ocean floor. Volcanic activity along the ocean floor may form undersea mountains, which can grow above the ocean's surface to become islands.

Suggested Activity:

Using appropriate AV materials, locate epicenters on a map using sample data.

Embedded Assessment: Identify geological features and internal forces that are associated with plate activity.

Summative Assessment: Identify problems associated with building in an earthquake prone area.

Theme: Systems

Process: Manipulating Information

Have you ever been in an area that had an earthquake? Why do earthquakes occur more in some locations than others? To try and answer this question, geologists map the number and intensity of earthquakes. *Locating Active Plate Boundaries* is a curriculum guide that helps you perform this same activity in the classroom. For copies of the entire lesson plan, contact Marge Bucheit at the University of Rhode Island (792-6596). The National Science Teachers Association also sells a complete earthquake curriculum module.

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THE PHYSICAL SETTING - Structure of Matter
Grade 3-5 (Benchmark 2 of 4)

By the end of the 5th grade all students will know that --

No matter how parts of an object are assembled, the weight of the whole object made is always the same as the sum of the parts; and when a thing is broken into parts, the parts have the same total weight as the original thing.

Suggested Activity:

Each pair of students has the same number and size of Lego blocks. Build any object with all blocks. Weigh the blocks loose and in object form.

| | |
|-----------------------|---|
| Embedded Assessment: | Observe measurement of objects. Record results in journal and write about the activity. |
| Summative Assessment: | Issue other materials and pose same problem. |
| Process: | Experimental Proficiency and Psychomotor Proficiency |
| Theme: | Models |

THE PHYSICAL SETTING - Structure of Matter
Grade 3-5 (Benchmark 3 of 4)

By the end of the 5th grade all students will know that --

Materials may be composed of parts that are too small to be seen without magnification.

Suggested Activity:

Mystery Powders (5) - Students use a hand lens to observe and compare the composition of white sand, baking soda, talc, sugar and salt.

| | |
|-----------------------|---|
| Embedded Assessment | Students will list 4 properties that make the 5 powders alike and different. |
| Summative Assessment: | Given a glass of water, a hand lens and 2 of the powders, students will identify the powders. |
| Theme: | Models |
| Process: | Experimental Proficiency |

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THE PHYSICAL SETTING - Structure of Matter
Grade 6-8 (Benchmark 1 of 7)

By the end of the 8th grade all students will know that --

All matter is made up of atoms, which are far too small to see directly through a microscope. The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.

Suggested Activities:

A series of activities that make the point that we can observe the effects of atoms without being able to see (sense) them directly. Student activity - make solutions of various materials (sugar, salt, colored solutes) - what happened? How do you know the substance is still there? Where did it go? Add a soluble solid to a beaker of water of known mass and observe change in mass as the solid dissolves. Fill a balloon with air-observe-how do you know there is something in there? A 'black box' activity. Students examine various samples of elements - aluminum, sulfur, iron, copper, lead, carbon, etc. to compare their properties. Examine water (H₂O) and Hydrogen Peroxide (H₂O₂) and have students add Manganese Dioxide (Mn₂O₂) to each and observe reactions and pose possible reasons for observed differences. Divide class into groups of 3 or 4 students. Each group uses a bag containing pieces of tinker toys. Each group's bag has the same pieces. Students are blindfolded and given 5/10 minutes to use all pieces to construct some item. At the end of the time limit each group displays their work. Discussion should be centered around why we have different products when all used the same materials.

| | |
|-----------------------|---|
| Embedded Assessment: | Scavenger hunt to locate elements outside the school setting. Observe whether students can develop a rationale to explain the differences between items produced. |
| Summative Assessment: | Defend the statement "All matter is made up of atoms." Include examples showing that atoms can be combined in different ways. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks |

'Periodic Table' videodisc and other software from Journal of Chem Education, published by the American Chemical Society, tel. 202-872-4388. For more complete information check Chapter 9 - References.

THE PHYSICAL SETTING - Structure of Matter
Grade 6-8 (Benchmark 2 of 7)

By the end of the 8th grade all students will know that --

Equal volumes of different substances usually have different masses.

Suggested Activity:

Have students determine the mass of two identical size cubes made of different materials of the same state. Use two balloons, fill one with air and one with water. Determine that the volumes are equal by measuring the circumference and calculating. Repeat the experiment with 2 gases like CO₂ (heavier than air) and He (lighter than air). Use different liquids.

Embedded Assessment: Have students determine the density of their samples.

Summative Assessment: Explain how equal volumes of different substances can have different masses.

Theme: Patterns

Process: Manipulating Information, esp. developing generalizations

From Mr. Palano's class, Northern Cumberland Middle School, Cumberland ...

Mr. Palano's second class of the day is his smallest, only eight students with a classroom aide. While teaching the concepts of density, mass and volume he is using a Computer Assisted Science Labs package. Students are instructed to select a variety of wooden blocks, measure the mass and volume using rulers and a triple-beam balance, and finally calculate the density. They work in pairs. As each pair completes a set of calculations, they move to a special computer workstation attached to a scale. They place their wooden block on the scale and enter their calculated values in the computer. In seconds the accurate results (mass, density and volume) are displayed on the screen, along with an accuracy rating from 0 to 5. Students know immediately if their measurements were very exact (rating of 4.7 or more), if they were close but not terribly accurate (between 4.2 and 4.7) or if they have made an error somewhere along the line. When they score below a 4.7 they go back to their stations and try to identify the problem. Mr. Palano circulates around the room, offering helpful advice at each station. Students let out a little cheer when the computer verifies their measurements as accurate. This activity will be repeated throughout the day with Mr. Palano's other classes. What makes this class unique is that the students are in a self-contained classroom for the rest of the day. Keeping the class size small and having a familiar classroom aide allows these students to fully participate in the eighth grade science laboratory experiences.

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THE PHYSICAL SETTING - Structure of Matter
Grade 6-8 (Benchmark 3 of 7)

By the end of the 8th grade all students will know that --

Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions.

Suggested Activity:

Place BB's (or any other small, round objects) into a plastic petri dish to about 1/3 full. Place petri dish on overhead projector to demonstrate each state of matter by increasing the speed of the BB's by moving the Petri dish on the overhead projector.

| | |
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| Embedded Assessment: | Have students identify which state of matter is represented by the teacher at differing stages of the demonstration. |
| Summative Assessment: | Students will design their own model to demonstrate molecular motion in the different states of matter. |
| Theme: | Models |
| Process: | Experimental Proficiency |

THE PHYSICAL SETTING - Structure of Matter
Grade 6-8 (Benchmark 4 of 7)

By the end of the 8th grade all students will know that --

The temperature and acidity of a solution influences reaction rates. Many substances dissolve in water, which may greatly facilitate reactions between them.

Suggested Activity:

Use 2 lightsticks in this demonstration. Put one in ice water and the other in warm water. Students should observe differences in intensity of light. Place equal amounts of cream of tartar and baking soda in a petri dish. Students should notice that they do not react. Then make saturated solutions of each substance. Then pour solutions together. Notice reaction.

| | |
|-----------------------|---|
| Embedded Assessment: | Students draw conclusions as to why there were differences in rates of reaction. |
| Summative Assessment: | Tell students that food spoilage is caused by chemical changes formulated by microorganisms. Have students explain why refrigeration is an effective way to prevent food spoilage. Research food preparation and handling codes and discuss why they are important. |
| Theme: | Change, Systems |
| Process: | Manipulating Information, esp. connecting new information with previous knowledge |

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THE PHYSICAL SETTING - Structure of Matter
Grade 6-8 (Benchmark 5 of 7)

By the end of the 8th grade all students will know that --

Scientific ideas about elements were borrowed from some Greek philosophers of 2,000 years earlier, who believed that everything was made from four basic substances: air, earth, fire, and water. It was the combination of these 'elements' in different proportions that gave other substances their observable properties. The Greeks were wrong about those four, but now over 100 different elements have been identified -some rare and some plentiful, out of which everything is made. Because most elements tend to combine with others, few elements are found in their pure form.

Suggested Activities:

Have students compare the Greek conception with present day theory. Make a chart of similarities and differences. A second activity would be to view the video listed in resources and have students list as many substances as are mentioned. Students can then identify which items in the list are elements.

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|-----------------------|--|
| Embedded Assessment: | Make a chart of similarities and differences from actual testing of element samples. |
| Summative Assessment: | Choose a substance or substances and have students explain its composition using both systems. |
| Theme: | Continuity and Change |
| Process: | Manipulating Information, esp. classifying |

The PBS Series 'Dimensions in Chemistry' would make an excellent resource here. Contact Channel 36, WSBE, at 277-3636.

THE PHYSICAL SETTING - Structure of Matter
Grade 6-8 (Benchmark 7 of 7)

By the end of the 8th grade all students will know that --

No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. The idea of atoms explains the conservation of matter: If the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same.

Suggested Activity:

Place small amount of baking soda in the corner of a 1 quart Plastic sandwich bag bag (minimum size). Also put in a tiny paper cup with vinegar in the same bag. Place entire bag on a scale and calculate weight. Turn bag upside down so that vinegar and baking soda mix. Allow gas to fill bag and reweigh. (Note: Be sure to test correct ratio of vinegar to baking soda before demonstrating.)

Embedded Assessment: Students should predict and justify what will happen when the bag is turned upside down.

Summative Assessment: Have teacher do a precipitate demonstration in an open system (beaker in a beaker). Students should predict what will happen to mass and justify their reactions.

Theme: Systems

Process: Experimental Proficiency

THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 1 of 9)

By the end of the 12th grade all students will know that --

Atoms are made of a positive nucleus surrounded by negative electrons. An atom's electron configuration, particularly the outermost electrons, determines how the atom can interact with other atoms. Atoms form bonds to other atoms by transferring or sharing electrons.

Suggested Activity:

Classroom demonstration of the reactivity of various elements, e.g., sodium's volatility vs. helium's inertness. Relate these demonstrations to the electron configuration and/or valence electrons of each respective element.

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|-----------------------|---|
| Embedded Assessment: | Student writes atomic configuration of elements and identifies and/or defines possibilities of ionic, covalent, and metallic bonds. |
| Summative Assessment: | Students will be given various elements and a periodic table. Student determines the configuration. For a given compound student will draw appropriate Lewis (electron dot) type diagram to indicate bonds. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks, esp. linking concepts/principles |

THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 2 of 9)

By the end of the 12th grade all students will know that --

Protons and neutrons, having a mass nearly two thousand times greater than the electron, compose the nucleus of the atom. The number of protons in an atom, called the atomic number, equals the number of electrons in the electrically neutral atom. The nucleus is a small fraction of the total volume of the atom. Atoms change their charge by adding or losing electrons. These atoms are then called ions.

Suggested Activity:

Build scale model of atom to illustrate the empty space and size involved. Relay to students the analogy of a flea on the pitcher's mound in a baseball stadium (the flea being the nucleus and the remainder of the stadium being the domain of the electrons). Demonstrate the presence of ions in an electrolytic aqueous solution using an electrical conductivity tester.

| | |
|-----------------------|---|
| Embedded Assessment: | Student writes the electron configuration of a given atom and its resultant ion and compares sizes using reference charts. |
| Summative Assessment: | Students will identify atoms from given electron configurations. Student will respond to the question: Why is the atom considered to have a volume that contains mostly empty space. Why are properties of atoms and ions of some elements different? |
| Theme: | Models |
| Process: | Manipulating Information, esp. developing generalizations |

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THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 3 of 9)

By the end of the 12th grade all students will know that --

Neutrons have a mass that is nearly identical to that of protons, but neutrons have no electric charge. Although neutrons have little effect on how an atom interacts with others, they do affect the mass and stability of the nucleus. Isotopes of the same element have the same number of protons (and therefore of electrons) but differ in the number of neutrons.

Suggested Activity:

Introduce what an isotope is to students, perhaps using hydrogen, deuterium, and tritium as examples. Their importance in the production of 'heavy water' or the fusion process should also be discussed.

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| Embedded Assessment: | Student, given appropriate data, should be able to determine the nuclear structure of a given isotope of an element. |
| Summative Assessment: | Student will describe the structure of a given atomic isotopes' nucleus and compare properties. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks, esp. linking concepts/principles |

THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 4 of 9)

By the end of the 12th grade all students will know that --

The nucleus of radioactive isotopes is unstable and spontaneously decays, emitting particles and/or wavelike radiation. It cannot be predicted exactly when, if ever, an unstable nucleus will decay, but a large group of identical nuclei decay at a predictable rate. This predictability of decay rate allows radioactivity to be used for estimating the age of materials that contain radioactive substances.

Suggested Activity:

Either as a lab or a demonstration show that a capacitor can be charged and slowly discharged. Use its slow discharge as an analogue to a decay rate. Data may be graphed and should resemble a decay curve. Introduce (through reading and/or discussion) the utility of radioactive decays. (Carbon-14 dating and radiation treatment of tumors are based upon such decay.)

| | |
|-----------------------|--|
| Embedded Assessment: | From given data students graphically can determine the decay curve for a radioactive element, and thus the half-life. |
| Summative Assessment: | Students using a radioactive analogue apparatus, such as a large number of multi-sided dice, can experimentally reproduce the probability curves of simulated radioactive decay, and thus determine the half-life, modeling this behavior. |
| Theme: | Models |
| Process: | Manipulating Information, esp. applying statistical procedures |

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THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 5 of 9)

By the end of the 12th grade all students will know that --

Scientists continue to investigate atoms and have discovered even smaller constituents of which electrons, neutrons, and protons are made.

Suggested Activity:

The film "Powers of Ten" could give students a nice insight into how small subatomic particles actually are.

| | |
|-----------------------|--|
| Embedded Assessment: | Stop the film at one or two preselected points and have students jot down their own thoughts and share them with at least one other student. |
| Summative Assessment: | Students evaluate the government decision to stop the construction of the 'super-collider' accelerator in Waxahachie, Texas. |
| Theme: | Continuity and Change |
| Process: | Proficiency in Reaching Decisions About Issues |

THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 6 of 9)

By the end of the 12th grade all students will know that --

The placement of elements on the periodic table of elements is determined by common chemical properties. The same sequence of properties appears over and over again in the list.

Suggested Activity:

Classroom demonstration of the reactivity of elements within the same family (e.g., sodium and potassium in water or magnesium and calcium in hydrochloric acid).

Embedded Assessment: Students predict from a periodic chart what elements have properties similar to a given element.

Summative Assessment: Given a periodic table, student identifies properties of a given element like acidity, reactivity, etc.

Theme: Models

Process: Developing Explanatory Frameworks.

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THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 7 of 9)

By the end of the 12th grade all students will know that --

Atoms often join with one another in various combinations in distinct molecules or in repeating three-dimensional crystal patterns. An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules.

Suggested Activity:

Growth of a crystal structure. Using given salts, students may develop a seed crystal by cooling a supersaturated aqueous solution of that given salt. That seed crystal may be suspended in the same supersaturated solution and grow slowly in near perfect three-dimensional patterns. Various PC software programs on crystal patterns and atomic motion are available.

Embedded Assessment: Students will recognize various basic crystal patterns, e.g., cubic or hexagonal close packed.

Summative Assessment: Given reference to crystalline forms, (e.g., Chem-Physics Handbook of CRC or Lange's Handbook of Chemistry) student can list or observe most frequent shapes.

Theme: Models

Process: Manipulating Information, esp. developing generalizations

THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 8 of 9)

By the end of the 12th grade all students will know that --

The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others.

Suggested Activity:

Using a student molecular kit (ball and spring set or comparable set), students may build three-dimensional models of various molecules. If the molecules are covalent in nature, the shapes may be correlated to the Valence Shell Electron Pair Repulsion (VSEPR) Theory, which predicts the shapes, bond angles, and consequent forces between atoms in a given molecule.

| | |
|-----------------------|--|
| Embedded Assessment: | Students will become adept at using the VSEPR theory to predict molecular shapes. |
| Summative Assessment: | Students, presented with the configuration of several atoms in a molecule, shall identify the molecule's properties. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks, esp. linking concepts/principles |

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THE PHYSICAL SETTING - Structure of Matter
Grade 9-12 (Benchmark 9 of 9)

By the end of the 12th grade all students will know that --

The rate of reactions among atoms and molecules depends on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. Some atoms and molecules are highly effective in encouraging the interaction of others.

Suggested Activity:

A laboratory activity known as the 'The Clock Reaction' or the 'Starch-Iodine Clock Reaction'. Students mix two clear solutions and in several seconds observe a dynamic color change. Upon heating, cooling, or diluting one of the original two solutions, the rate of reaction will vary.

| | |
|-----------------------|---|
| Embedded Assessment: | Students will understand the concept of a <u>reaction mechanism</u> and how it actually plays a role in the rate of reaction by constructing a data table and analyzing the data. |
| Summative Assessment: | Student should be able to describe the factors affecting the rate of reaction between chemical substances. |
| Theme: | Models |
| Process: | Manipulating Information, esp. identifying patterns and relationships |



*From Mr. Maruszczak's Class
Ponaganset High School
Foster-Glocester, Rhode Island
Tenth Grade Activity*

A Constructivist Approach to Science

"Given the realities of our current world, the concept of Science Literacy can best be achieved at Ponaganset High School by using multiple resources rather than relying on a single textbook; by involving students directly with hands-on experiences in responding to the issues of science; by working cooperatively in groups; by utilizing all forms of instructional technology; by students developing their own relevant database (notebooks); and by immersion into relevant issues as the focus of study ... The spirit of inquiry, which characterizes all human curiosity, becomes the primary concept in discovering the sciences. The question 'Why?' becomes paramount and invites a response which functions within an orderly pattern and one which suggests useful applications for our world. This, then, rather than some specific 'scientific' dogma is the heart of this program."

from Science for All Students, Ponaganset High School's two year integrated science curriculum based on the concepts of Project 2061.

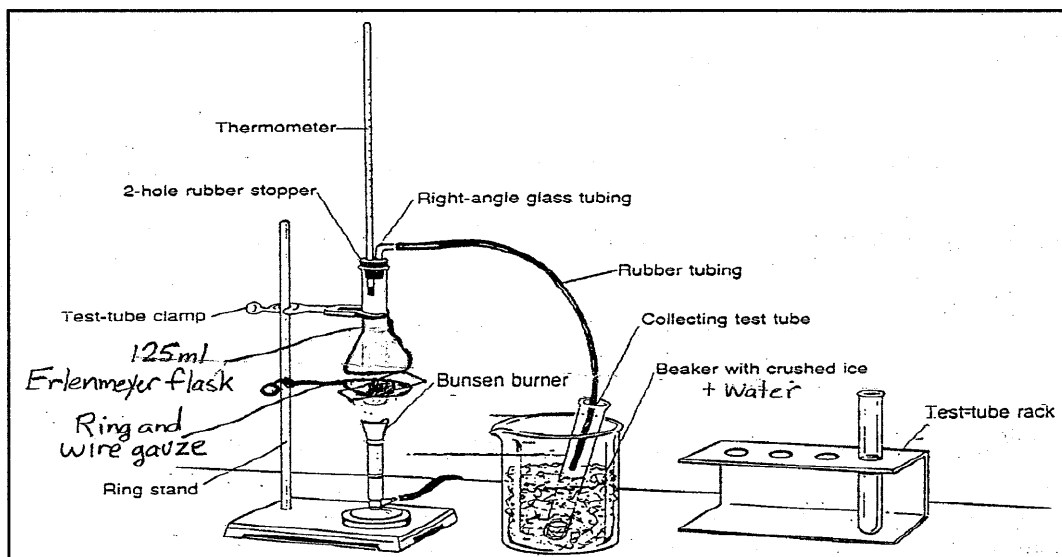
This particular lab is an example of an activity re-written for a more inquiry-based or constructivist approach. With the release of Ponaganset's new science curriculum, many lab activities were re-written, making them less 'cookbook' in nature. Activities are now designed to be purposeful, research-based, and aligned with student behavioral goals. (Making an activity 'hands-on' does not necessarily make it worthwhile and educational!)

The following information is copied and distributed to the students:

Fractional Distillation ... What Good Is It Anyway?

- 1. Using a graduated cylinder, obtain 25 ml of the liquid mixture that I mixed in front of the class. Remove the 2-hole rubber stopper from the Erlenmeyer flask and pour in the mixture.*
- 2. Be sure that the thermometer is near the top of the neck of the Erlenmeyer flask, NOT in the liquid. Place a few boiling chips in the Erlenmeyer flask. Now put the 2-hole stopper back on the flask, making sure that the flask is firmly clamped in place, and everything is stable.*

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YOUR SET-UP SHOULD LOOK LIKE THE PICTURE ABOVE

3. Light the Bunsen Burner. **WORK WITH A LOW TO MODERATE SIZE FLAME!!!** Very slowly heat the mixture. Do not allow the liquid to boil rapidly. If it does, remove it from the flame.
4. At what temperature do you notice that the mixture starts to boil?? You should notice that a liquid is beginning to collect in the test tube in the beaker of ice water. (CAUTION: Do not allow the rubber tubing to touch the liquid being collected.) Describe the physical characteristics (color, smell, appearance, etc.) of the liquid which is being collected. What liquid do you believe this to be? Why? Explain.
5. When the temperature begins rising again, remove the collecting test tube from the ice water and replace it with an empty test tube. Place the test tube with the collected liquid in the test tube rack.
6. The temperature will stop rising again. At what temperature do you notice this happens?? You should begin to notice a liquid again collecting in the second test tube. (Again, do not allow the rubber tubing to touch the liquid being collected.) Describe the physical characteristics of the liquid which is being collected. What liquid do you believe this to be? Why? Explain.
7. When the temperature begins rising again, turn off the Bunsen burner and allow the heated Erlenmeyer flask to cool. Describe fully the physical characteristics of the liquid left behind in the Erlenmeyer flask. What can you say about its boiling point?
8. All liquids may be discarded down the drain. Clean the Erlenmeyer flask once it is cool enough.

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9. Did the complete separation of all three liquids that make up the mixture take place? If not, what could you do to make each liquid more pure? Explain.
10. The process you just performed in the lab is known as FRACTIONAL DISTILLATION. How do you know that fractional distillation is a physical separation, not a chemical one?
11. Describe a mixture that would be really DIFFICULT to separate different liquids by fractional distillation. Explain completely.
12. Where is the process of fractional distillation used in the real world? Describe how it is useful.

Student involvement and enthusiasm are very high. Students MAY exhibit more confusion/trepidation because less specific information is given them. However, they are challenged to a higher level, and their work becomes more meaningful as they have to identify problems, make decision, convey an understanding of what they are working with, be curious, and apply THEIR RESEARCH to the existing body of knowledge. Essentially we are asking kids to take a step beyond their prior experiences.

A helpful supplemental reading on this is "Cooking and Constructivism," *The Science Teacher*, February 1994, pp. 34-37.

THE PHYSICAL SETTING - Energy Transformations
Grade 6-8 (Benchmark 1 of 2)

By the end of the 8th grade all students will know that --

Energy cannot be created or destroyed, but only changed from one form into another. Most of what goes on in the universe--from exploding stars and biological growth to the operation of machines and the motion of people--involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation. Energy appears in different forms. Heat energy is in the disorderly motion of molecules; chemical energy is in the arrangement of atoms; mechanical energy is in moving bodies or in elastically distorted shapes; gravitational energy is in the separation of mutually attracting masses.

Suggested Activity:

Have each student take a paper clip and bend it back and forth 15-20 times and then feel the heat generated by motion. Demonstration of palm glasses, radiometer, doorbells are also pertinent.

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| Embedded Assessment: | Students tabulate their findings listing the energies involved in each of the activities. |
| Summative Assessment: | Students to make list of all energy transformations they can identify in their homes. |
| Theme: | Continuity and Change |
| Process: | Manipulating Information, esp. inferring |

THE PHYSICAL SETTING - Energy Transformations
Grade 6-8 (Benchmark 2 of 2)

By the end of the 8th grade all students will know that --

Heat can be transferred through materials by the collisions of atoms (conduction) or across space through radiation. If the material is fluid, currents will be set up in it that aid the transfer of heat (convection).

Suggested Activity:

Use dabs of butter or drops of wax along a length of coat hanger (knitting needle) and hold end in candle to show heat traveling down the solid. Take two equal size bottles; fill one with hot water and one with cold water. Put food coloring in the hot water. Place the bottle of cold water on the top of the bottle with hot water so that the hot and cold water will mix. Students can see the current of dye. A flat iron can be used to show that a hand that is placed 12" from an iron is heated but the air in between still remains cool.

Embedded Assessment: Redo the hot and cold water demonstration and reverse the order of the bottles. Ask students to predict the results and justify their reasoning.

Summative Assessment: Have students explain "a day at the beach." Students should explain why even though the air temperature may be 90 degrees the water feels cold and the sand feels hot. They should use all three methods of heat transfer in their explanations.

Theme: Systems

Process: Developing Explanatory Frameworks, esp. linking concepts/principles

THE PHYSICAL SETTING - Energy Transformations
Grade 9-12 (Benchmark 1 of 6)

By the end of the 12th grade all students will know that --

Whenever the amount of energy in one place or form diminishes, the amount in other places or forms increases by the same amount. (The Law of Conservation of Energy)

Suggested Activity:

Set up a pendulum (large or small) and show that it returns to almost the same height at which it starts. Ask students why it doesn't return to exactly the same position and where the rest of the energy goes.

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| Embedded Assessment: | Using the pendulum demonstration define potential and kinetic energy and indicate which type exists at various points of the arc. |
| Summative Assessment: | Transferring hot water to cold water allows students to calculate and measure heat transference. |
| Theme: | Systems |
| Process: | Developing Explanatory Frameworks, esp. creating/testing physical models |

THE PHYSICAL SETTING - Energy Transformations
Grade 9-12 (Benchmark 2 of 6)

By the end of the 12th grade all students will know that --

Heat energy in a material consists of the disordered motions of its atoms or molecules. In any interactions of atoms or molecules, the statistical odds are that they will end up with less order than they began--that is, with the heat energy spread out more evenly. With huge numbers of atoms and molecules, the greater disorder is almost certain. This disorder is called entropy.

Suggested Activities:

Teacher can demonstrate randomness of systems by using an air-based popcorn popper. The popcorn popper is filled with kernels, a 400 ml. beaker is placed underneath the popper, the popper is turned on. As the popcorn pops, kernels in an ordered system (inside machine) spread out and become disordered as some reach the beaker while others fly about and reach the tabletop. Students can demonstrate randomness of systems by using ping pong balls, racks, and pool cues or yardsticks and the floor. The racks can be made by the teacher or students from cardboard in a triangular shape. Students somehow mark the starting point, rack the ping pong balls on the floor, remove rack, hit the group of balls with cue or yardstick gently. Position of the balls is measured from the starting point and later graphed. Students can demonstrate randomness of systems by using a beaker (400 ml), ice cubes, tap water at room temperature and Celsius thermometer. Students fill a 400 ml beaker to 300 ml. line. Students measure temperature of the water using a Celsius thermometer. Students mark the beaker on the sides at N, S, E, W with a grease pencil. Each student obtains an ice cube (known to be at 0 Celsius). The ice cube is placed in the water. Temperature of the beaker is taken every five minutes at each compass position. Students should record the temperatures throughout the class period. Students create a graph with temperature vs. time, graphing each position (N, S, E, or W) in different color markers or pencil.

Embedded Assessment: Student successfully takes required temperature readings, records these and constructs a graph of temperatures for all of the four positions.

Summative Assessment: Students are given a few tables of temperature readings for various solutions. Students examine each table to decide if system is becoming more or less disordered. After deciding, students must explain in written form how they arrived at their decision.

Theme: Continuity and Change

Process: Manipulating Information

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THE PHYSICAL SETTING - Energy Transformations
Grade 9-12 (Benchmark 3 of 6)

By the end of the 12th grade all students will know that --

Transformations of energy usually produce some energy in the form of heat, which spreads around by radiation, conduction or convection into cooler places. Although just as much total energy remains, its being spread out more evenly means less can be done with it.

Suggested Activity:

Student has a battery, small bare copper wire or aluminum foil, small light bulb or brass fastener. Students should feel the wire or foil to determine its relative hotness or coldness. Students set up circuit between battery, leads, and light (or fastener). Circuit is completed for a few minutes. Students should feel the wire (or foil) to determine its relative hotness or coldness. Discussion should also mention heat loss in engines, such as car engines and mufflers. Discuss heat loss due to friction.

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| Embedded Assessment: | Students successfully assemble circuit, note before and after temperatures, recognize that electrical energy produces heat (which serves no useful purpose in this situation). |
| Summative Assessment: | Student finds three other examples of heat energy produced by transformations of energy (electrical to light, electrical to heat such as an iron cord) from his/her experience and describes the energy transformation in written form including how the 'useless' heat is produced and how this heat affects the environment. |
| Theme: | Systems |
| Process: | Experimental Proficiency |

THE PHYSICAL SETTING - Energy Transformations
Grade 9-12 (Benchmark 4 of 6)

By the end of the 12th grade all students will know that --

Different energy levels are associated with different configurations of atoms and molecules. Some changes of configuration require an input of energy whereas others release energy.

Suggested Activity:

Perform heat of solution of sulfuric acid experiment, or other simple demonstrations of exothermic and endothermic reactions in class.

Embedded Assessment:

Determine the numerical heat of solution for sulfuric acid.

Summative Assessment:

Students will understand the thermodynamics of both exothermic and endothermic reactions.

Theme:

Systems

Process:

Manipulating Information, esp.
interpreting/evaluating data

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THE PHYSICAL SETTING - Energy Transformations
Grade 9-12 (Benchmark 5 of 6)

By the end of the 12th grade all students will know that --

When energy of an isolated atom or molecule changes, it does so in a definite jump from one value to another, with no possible values in between. The change in energy occurs when radiation is absorbed or emitted, so the radiation also has distinct energy values. As a result, the light (radiation) emitted or absorbed by separate atoms or molecules (as in a gas) can be used to identify what the substance is.

Suggested Activity:

Students will be given appropriate information regarding energy levels of electrons, energized electrons, release of electron energy as light, ground state electron spectroscopy. Students observe various gas discharge tubes using diffraction gratings. Students make notes and create spectral patterns on pieces of white paper. Spectral lines are spaced and colored to approximate what was observed. Students explain, in written form, what individual lines represent and why spectral patterns are different.

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| Embedded Assessment: | Student successfully draws spectral patterns, explains patterns of individual gases and what each spectral line represents, relating the configuration patterns to spectral changes. |
| Summative Assessment: | Student explains the impossibility of two or more elements or compounds leaving the same spectral patterns by describing electrons in ground and excited states. |
| Theme: | Models |
| Process: | Manipulating Information, esp. identifying patterns and relationships |

THE PHYSICAL SETTING - Energy Transformations
Grade 9-12 (Benchmark 6 of 6)

By the end of the 12th grade all students will know that --

Energy is released whenever the nuclei of very heavy atoms, such as uranium or plutonium, split into middleweight ones (a process known as 'fission'), or when very light nuclei, such as those of hydrogen and helium, combine into heavier ones (a process known as 'fusion'). The energy released in each nuclear reaction is very much greater than the energy given off in each chemical reaction.

Suggested Activity:

Research the mass involved in nuclear and conventional fuels to produce the same quantity of energy. Introduce conservation of mass and energy, $E=mc^2$ and the impact such a discovery has made on human society in the twentieth century.

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| Embedded Assessment: | Students will be able to read and interpret a nuclear reaction equation. |
| Summative Assessment: | Students will realize that both fusion and fission reactions obey the law of conservation of matter and energy even though they give off great amounts of energy. |
| Theme: | Constancy & Change |
| Process: | Developing Explanatory Frameworks, Creating Mental Models |

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THE PHYSICAL SETTING - Motion
Grade K-2 (Benchmark 1 of 3)

By the end of the 2nd grade all students will know that --

Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.

Suggested Activity:

Go outside and categorize everything you see moving. Use the categories given in the benchmark.

Embedded Assessment: Students use movement terms appropriately. Do the 'hokey-pokey'.

Summative Assessment: Ask students to give instructions to other students or to complete a maze using only words to guide them.

Theme: Constancy and Change

Process: Psychomotor Proficiency, Language Proficiency

THE PHYSICAL SETTING - Motion
Grade K-2 (Benchmark 2 of 3)

By the end of the 2nd grade all students will know that --

The way to change how something is moving is to give it a push or a pull.

Suggested Activities:

Assemble tinker toys -- construct and use cars. Use carts, elastic, balloons, playground equipment, medicine ball/tug of war to illustrate the benchmark.

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| Embedded Assessment: | Teacher will use toys that demonstrate push or pull. Student will identify which toys utilize push or pull. |
| Summative Assessment: | Give a series of pictures of machines and ask students to determine which are pulled or pushed. |
| Theme: | Continuity and Change |
| Process: | Experimental Proficiency, esp. comparing, observing |

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THE PHYSICAL SETTING - Motion
Grade K-2 (Benchmark 3 of 3)

By the end of the 2nd grade all students will know that --

Sound is caused by vibration.

Suggested Activity:

Children will use a variety of items such as cymbals, hair combs and rulers, to produce sounds and record the physical evidence of how things that make sound vibrate. Have students place their hand on their neck and begin speaking. Discuss what happens when they speak louder.

Embedded Assessment: Children will record on a chart physical evidence of vibration using three senses, visual, auditory, tactile.

Summative Assessment: Construct a Styrofoam cup phone. Have students describe what happens when they talk and listen. In addition list other items that vibrate.

Theme: Constancy and Change

Process: Psychomotor Proficiency, Experimental Proficiency

Contact someone in your school or district who works with the hearing impaired and have them visit your class.

THE PHYSICAL SETTING - Motion
Grade 6-8 (Benchmark 1 of 5)

By the end of the 8th grade all students will know that --

Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white. Other things that give off or reflect light have a different mix of colors.

Suggested Activity:

Demonstrate spectrum by placing a prism in front of a white light source (e.g., slide projector). Later place differing colored cellophane or gel strips in front of lens to show how spectrum changes. By using diffraction gratings students can observe indirect sunlight to observe differences between sunlight and white light.

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| Embedded Assessment: | Compare the changes in each observation. |
| Summative Assessment: | Have students draw and label a spectrum and then have them explain how it would change if the light source color changed. |
| Theme: | Constancy and Change |
| Process: | Experimental Proficiency, esp. observing, comparing |

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THE PHYSICAL SETTING - Motion
Grade 6-8 (Benchmark 2 of 5)

By the end of the 8th grade all students will know that --

Something can be "seen" when light waves emitted or reflected by it enter the eye--just as something can be "heard" when sound waves from it enter the ear.

Suggested Activity:

Demonstrate projection of an image (pinhole device or lens); Make shoebox with a picture at one end and two holes at the other. Have students view the picture through one hole with the second hole closed. Do the same activity with both holes open.

Embedded Assessment: By drawing a diagram, students trace the path of light from the object to the image.

Summative Assessment: Compare how a camera works to how the eye works or compare the way you see to the way you hear.

Theme: Models

Process: Developing experimental proficiency, esp. creating/ testing mental models



*From Ms. Leonard's Class
Blessed Sacrament School
Providence, Rhode Island
Eighth Grade Activity*

Using Research to Inform Instruction

The majority of elementary students and some middle school students who have not received any systematic instruction about light tend to identify light with its source (i.e., a light bulb) or its effect (i.e., a patch of light). They do not have a notion of light as something that travels from one place to another. Hands-on exploration activities that engage students will help increase the understanding of scientific concepts and make the science classroom a more positive place.

Ms. Leonard has been using some exciting and fun activities to explore and reinforce the concepts of how light waves travel.

The Color Wheel - You'll need some colored paper (yellow, orange, green, purple, and red), a glue stick, a pencil, cardboard, and scissors. Draw a circle on the cardboard and cut it out. With the pencil, draw six equal parts out of the circle. Cut one piece of each one of the colors and glue them onto the cardboard. Punch a hole through the center of the circle to produce a 'top' like figure. Put the pencil through the hole, and holding the pencil, spin the wheel fast and watch what happens! What colors can you see? Do you always see the same color? Why?

Shadows - You'll need construction paper, thin sticks, scissors, flashlight, and tape. Have students cut out a few crazy characters from the construction paper. Emphasize that the shape should have some holes in it. Carefully tape them onto the thin stick (a yardstick works well). Holding the flashlight, ask a volunteer to work the puppet. Turn off all the lights and shine the flashlight on the puppet up against the wall. Can you make this image bigger or smaller? What does this prove to you about how light waves travel?

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THE PHYSICAL SETTING - Motion
Grade 6-8 (Benchmark 3 of 5)

By the end of the 8th grade all students will know that --

An unbalanced force acting on an object changes its speed or path of motion, or both. If the force acts toward a single center, the object's path may curve into an orbit around the center.

Suggested Activity:

Any of several demonstrations of inertia could be done by students, such as the card and coin. Demonstrate centripetal force using two weights connected by a string threaded through a spool or rubber stopper.

Embedded Assessment:

Have students explain the behavior of the coin in the demo.

Summative Assessment:

Have students simulate their motion in a car as the car changes speed and direction (as a group activity). Individually, have students explain why they move as they do.

Theme:

Constancy & Change

Process:

Developing Explanatory Frameworks

THE PHYSICAL SETTING - Motion
Grade 6-8 (Benchmark 4 of 5)

By the end of the 8th grade all students will know that --

Vibrations in materials set up wavelike disturbances that spread away from the source. Sound and earthquake waves are examples. These and other waves move at different speeds in different materials.

Suggested Activity:

Have students observe the effect of a tuning fork on a pan of water. Compare this to what happens when an object is dropped into water. Have students listen to the transmission of sound through various solids (hold base of tuning fork against the solids).

Demonstrate the difference in the speed of light in different mediums by placing a straw in an empty glass, in a glass of water, in a glass of glycerol, and in a glass of alcohol. Because light travels at different speeds in each of these liquids, students will perceive the straw to be bending at various angles.

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| Embedded Assessment: | Describe what happens when a pebble is dropped in still water. |
| Summative Assessment: | Have students design a demonstration to show the patterns formed as waves move away from a source. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks |

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THE PHYSICAL SETTING - Motion
Grade 6-8 (Benchmark 5 of 5)

By the end of the 8th grade all students will know that --

Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation--visible light. Differences of wavelength within that range are perceived as differences in color.

Suggested Activity:

Discuss examples of the electromagnetic spectrum that students are familiar with (UV, IR, microwave, X-, radio, and visible light). Discuss infrared photography, "black light", etc. Relate differences to wavelength. Demonstrate infrared goggles.

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| Embedded Assessment: | Create a large classroom spectrum. Have students bring in various examples of radiant energy and match them to regions of the spectrum. |
| Summative Assessment: | As a cooperative learning exercise have students assemble a spectrum from a series of pieces (examples and wavelengths in scientific notation) |
| Theme: | Scale |
| Process: | Manipulating Information, esp. identifying patterns and relationships |

Invite an opthamologist or school nurse to visit the class and bring a model of the eye. Ask the doctor or nurse to explain how the eye works, vision testing especially with the use of pinhole testers, some common vision problems, current research, and details of his or her own training. Extend inquiry at this point to incorporate color blindness: tests for, causes, compensatory techniques, role of heredity. This is an opportunity to integrate a project with the art department - have students design a poster to screen for color blindness.

The discovery/invention of each of the familiar examples of the electromagnetic spectrum (UV, IR, micro-, X-, radio-, etc.) should be investigated in conjunction with the history department. As a class, design a questionnaire to be used as the basis of interviews to be conducted on-site at a photography studio. The on-site visits should include opportunities to see the equipment, and conduct the interviews regarding functioning of the site, uses of the product, problems solved and training of all employees.

THE PHYSICAL SETTING - Motion
Grade 9-12 (Benchmark 1 of 6)

By the end of the 12th grade all students will know that --

The change in motion of an object (the acceleration) is proportional to the applied force and inversely proportional to the mass.

Suggested Activity:

Using an air puck (or air track) and elastic band launcher, show that as the number of elastic bands (force) increases, the acceleration increases. Using the same apparatus with only 1 elastic band, show that as the mass of the puck increases, the acceleration decreases.

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| Embedded Assessment: | Predict the outcome of changing the forces or masses involved in this activity. |
| Summative Assessment: | Compare the resulting acceleration when switching engines with a motorcycle and a dump truck. |
| Theme: | Models |
| Process: | Manipulating Information, esp. developing generalizations |

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THE PHYSICAL SETTING - Motion
Grade 9-12 (Benchmark 2 of 6)

By the end of the 12th grade all students will know that --

All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion.

Suggested Activity:

Discuss the motion of 2 cars traveling in the same direction. One travels at 50 mph, the other at 55 mph. Discuss what happens if you drop something in a moving vehicle. In which direction does it fall? Have students construct their own experiment at home while traveling in a car.

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| Embedded Assessment: | The student should be able to discuss the speed of the cars relative to each other and relative to the earth. |
| Summative Assessment: | Perform the same discussion and assessment when the cars are traveling in opposite directions. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks, esp. making testable predictions |

THE PHYSICAL SETTING - Motion
Grade 9-12 (Benchmark 3 of 6)

By the end of the 12th grade all students will know that --

Accelerating electric charges produce electromagnetic waves around them. A great variety of radiations are electromagnetic waves: radio waves, microwaves, radiant heat, visible light, ultraviolet radiation, x rays, and gamma rays. These wavelengths vary from radio waves, the longest, to gamma rays, the shortest. In empty space, all electromagnetic waves move at the same speed--the "speed of light."

Suggested Activity:

Using a diffraction grating or prism, break white light into component parts and compare it to a spectrum chart with wavelengths.

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| Embedded Assessment: | Given two colors, determine which has a longer wavelength. |
| Summative Assessment: | Write a paragraph describing similarities and differences between several wavelengths of the electromagnetic radiation. |
| Theme: | Models |
| Process: | Manipulating Information, esp. interpreting/evaluating data |

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THE PHYSICAL SETTING - Motion
Grade 9-12 (Benchmark 4 of 6)

By the end of the 12th grade all students will know that --

Whenever one thing exerts a force on another, an equal amount of force is exerted back on it.

Suggested Activity:

Have two students lock together two force scales of the 10 newton type. Have one student pull on their scale while the other keeps the other scale still. Both scales should register the same force on the dials.

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| Embedded Assessment | Students should be able to reason that the scales are dividing the same force, one pull and the other resistance. |
| Summative Assessment: | Students should be able to describe the forces meeting on a box that is being moved, and what happens when they push on a wall. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks, esp. linking concepts/principles |

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THE PHYSICAL SETTING - Motion
Grade 9-12 (Benchmark 5 of 6)

By the end of the 12th grade all students will know that --

The observed wavelength of a wave depends upon the relative motion of the source and the observer. If either is moving toward the other, the observed wavelength is shorter; if either is moving away, the wavelength is longer. This is known as the Doppler Effect. Because the light seen from almost all distant galaxies has longer wavelengths than comparable light here on earth, astronomers believe that the whole universe is expanding.

Suggested Activity:

Using a ribbed hose, students will swing the hose over their head and listen to the sounds being produced. Sound should be one pitch or frequency near the source and another pitch or frequency away from the source. Ask students to relate this phenomenon to applications of a radar gun in sports and traffic speed control.

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| Embedded Assessment | Students should recognize when the source is near and when it is more distant by the frequency of the sound. |
| Summative Assessment: | Students should be able to transfer their knowledge about sound behavior to light behavior, recognizing that sound and light both travel in waves. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks, esp. linking concepts/principles |

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THE PHYSICAL SETTING - Motion
Grade 9-12 (Benchmark 6 of 6)

By the end of the 12th grade all students will know that --

Waves can superpose on one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material. All these effects vary with wavelength. The energy of waves (like any form of energy) can be changed into other forms of energy.

Suggested Activity:

Have students observe a laser beam passing through the air to a target on the wall. Spraying water mist on the beam can show the beam in the air. The beam can then be passed through different materials to show the effect. Students may also work with a wave tank and generate water waves with various wavelengths and demonstrate various wave properties, such as reflection, refraction, diffraction, and interference.

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| Embedded Assessment | Students can predict the effect of the beam as it strikes different materials. |
| Summative Assessment: | Given a list of materials students can identify which materials will absorb, reflect, or transmit the laser beam. |
| Theme: | Models |
| Process: | Developing Explanatory Frameworks, esp. making testable predictions/attempting refutations |

THE PHYSICAL SETTING - Forces of Nature
Grade K-2 (Benchmark 2 of 2)

By the end of the 2nd grade all students will know that --

Magnets can be used to make some things move without being touched.

Suggested Activity:

Demonstrate and/or have students experience the dancing paper clip, mazes with magnetic marbles, hidden magnet under desk.

Embedded Assessment: What makes these things move?

Summative Assessment: Given a pan of sand and iron filings, students will determine how to separate iron filings from the sand without the magnet touching the sand.

Theme: Models

Process: Experimental Proficiency

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THE PHYSICAL SETTING - Forces of Nature
Grade 6-8 (Benchmark 1 of 3)

By the end of the 8th grade all students will know that --

Every object exerts gravitational force on every other object. The force depends on how much mass the objects have and on how far apart they are. The force is hard to detect unless at least one of the objects has a lot of mass.

Suggested Activity:

Discuss ways we know that both the earth and moon have gravity. Reinforce with videos, NASA, etc. Compare earth's and moon's gravity - discuss why they are different. Extend the description to other planets.

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| Embedded Assessment: | Have students explain why they would have a greater weight on Jupiter. |
| Summative Assessment: | Distribute a chart of several planets - their relative positions and relative masses. Have students predict their relative weights on these planets. Graph mass and gravitational pull of the planets. Discuss relationship. |
| Theme: | Systems |
| Process: | Manipulating Information, esp. interpreting/evaluating data |

THE PHYSICAL SETTING - Forces of Nature
Grade 6-8 (Benchmark 2 of 3)

By the end of the 8th grade all students will know that --

The sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them.

Suggested Activity:

Use a light and heavy object threaded through a spool. The spinning objects represent two planets in their orbits, and the spool represents the sun (demonstration).

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| Embedded Assessment: | Have students relate how this compares to a moon revolving around a planet and a planet around the sun. |
| Summative Assessment: | You are in the year 2061. Your work is on a newly launched space station. Explain why it will not fall to earth. |
| Theme: | Models |
| Process: | Manipulating Information, esp. developing generalizations |

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THE PHYSICAL SETTING - Forces of Nature
Grade 6-8 (Benchmark 3 of 3)

By the end of the 8th grade all students will know that --

Electric currents and magnets can exert a force on each other.

Suggested Activity:

Give students pairs of unmarked magnets and ask them to experiment with attraction and repulsion. Make a coil about 3" in diameter of #20 bellwire (about 50 turns). Attach both ends of the coil to a galvanometer. Have students pass magnets in and out of the coil rapidly.

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| Embedded Assessment: | Make a table summarizing your findings. |
| Summative Assessment: | Using a doorbell, explain how magnetism and electricity make a bell operate. |
| Theme: | Systems |
| Process: | Developing Explanatory Frameworks, esp. linking concepts and principles |

THE PHYSICAL SETTING - Forces of Nature
Grade 9-12 (Benchmark 1 of 6)

By the end of the 12th grade all students will know that --

Gravitational force is an attraction between masses. The strength of the force is proportional to the masses and weakens rapidly with increasing distance between them.

Suggested Activity:

Perform the Cavendish experiment. The force of gravitation between two movable or stationary spheres can be measured by observing, with the help of a mirror and light beam, the amount of bend in the fiber suspending the two spheres.

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| Embedded Assessment | Students will be able to correctly solve the problem |
| Summative Assessment: | Students will be able to predict in general terms how an increase or decrease in one mass will affect the gravitational force between the two. |
| Theme: | Systems |
| Process: | Developing Explanatory Frameworks, esp. making testable predictions/attempting refutation |

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THE PHYSICAL SETTING - Forces of Nature
Grade 9-12 (Benchmark 3 of 6)

By the end of the 12th grade all students will know that --

There are two kinds of charges--positive and negative. Like charges repel one another, opposite charges attract. In materials, there are almost exactly equal proportions of positive and negative charges, making the materials as a whole electrically neutral. Negative charges, being associated with electrons, are far more mobile in materials than positive charges are. A very small excess or deficit of negative charges in a material produces noticeable electric forces.

Suggested Activity:

Have students construct a simple electronic motor or take a motor apart. Let students feel the effects of touching a Van de Graaf generator. Teacher may demonstrate attractive and repulsive forces using wool, a pith ball, and plastic rod.

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| Embedded Assessment | Given directions students will be able to construct a working electric motor. |
| Summative Assessment: | Students will be able to describe how the electrical and magnetic forces interact in an electric motor. |
| Theme: | Models |
| Process: | Developing explanatory frameworks, esp. linking concepts/principles |

THE PHYSICAL SETTING - Forces of Nature
Grade 9-12 (Benchmark 4 of 6)

By the end of the 12th grade all students will know that --

Different kinds of materials respond differently to electric forces. In conducting materials such as metals, electric charges flow easily, whereas in insulating materials such as glass, they can move hardly at all. At very low temperatures, some materials become superconductors and offer no resistance to the flow of current. In between these extremes, semiconducting materials differ greatly in how well they conduct, depending on their exact composition.

Suggested Activity:

Have students test the electrical conductivity of various materials using a battery and bulb set up. Introduce students to superconductivity through a demonstration.

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| Embedded Assessment | Student will make generalizations about conductors and non-conductors. |
| Summative Assessment: | Given a list of 20 materials students will be able to distinguish the conductors and non-conductors. |
| Theme: | Constancy and Change |
| Process: | Manipulating Information, esp. classifying |

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THE PHYSICAL SETTING - Forces of Nature
Grade 9-12 (Benchmark 6 of 6)

By the end of the 12th grade all students will know that --

The forces that hold the nucleus of an atom together are much stronger than the electromagnetic force. That is why such great amounts of energy are released from the nuclear reactions in the sun and other stars.

Suggested Activity:

View films about nuclear reaction, like "The Universe" which is available through the Curriculum Center at RIC.

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| Embedded Assessment | Recognize the importance of nuclear fusion and its effect on living things. |
| Summative Assessment: | Be able to describe the effects of radiation on humans as well as the benefits of power generation from the sun. |
| Theme: | Constancy and Change |
| Process: | Manipulating Information, esp. developing generalizations |